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CONTROL OF LARVAE OF THE JAPANESE AND THE ASIATIC BEETLES IN LAWNS AND GOLF COURSES

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INTRODUCTION

The Japanese beetle (*Popillia japonica* Newman), the Asiatic beetle (*Anomala orientalis* Waterhouse), and the Asiatic garden beetle (*Autoserica castanea* Arrow) have become established at several localities in the eastern part of the United States. The larvae of these beetles feed on the roots of grass, and, where abundant, cause severe damage to lawns and golf courses. Research has been carried on for several years with the object of developing effective methods of protecting turf from the ravages of these insects. Poisoning turf with lead arsenate to control larvae of the Japanese beetle was developed at this laboratory,[1] and it has since been found to be effective in protecting turf from injury by the Asiatic beetle and the Asiatic garden beetle.[2] The treatment is now used extensively for this purpose on lawns and golf greens. The purpose of this circular is primarily to furnish interested persons with information on the most satisfactory procedures for protecting turf from injury by the larvae of these insects.

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[2] Friend, R. B. THE ASIATIC BEETLE IN CONNECTICUT. Conn. Agr. Expt. Sta. Bul. 304, p. [581]–664, illus. 1929.

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LIFE HISTORY AND HABITS OF THE BEETLES

The larvae of these beetles are similar in appearance to native white grubs. The appearance of a fully developed larva of the Japanese beetle is shown in Figure 1. The life history of the Japanese beetle is shown graphically in Figure 2. The adults appear in June and immediately begin to deposit eggs, preferably in well-kept lawns and golf courses. The period of oviposition extends throughout July and August. The eggs hatch in a few days, and the young larvae begin to feed on roots and humus immediately below the surface of the ground. The depth at which the larvae continue to feed in the soil during the active season is dependent upon the moisture. When the soil is moist, they are close to the surface, but when the upper layer of the ground becomes dry, they burrow downward until soil having a satisfactory degree of moisture is reached. The larvae grow rapidly, causing more damage as their root-consuming capacity increases, and become fully developed in the early fall. The most pronounced injury to turf usually appears in the fall, particularly if the season is dry. As cold weather approaches, the larvae burrow deeper into the soil, where they remain comparatively inactive during the winter. In the spring they return to the surface, feed for a few weeks, and then transform into adult beetles.

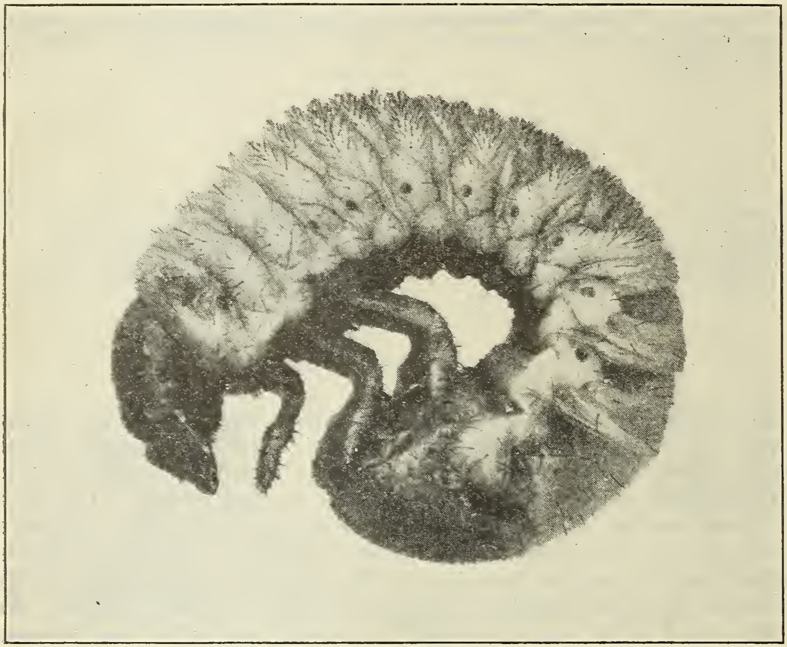
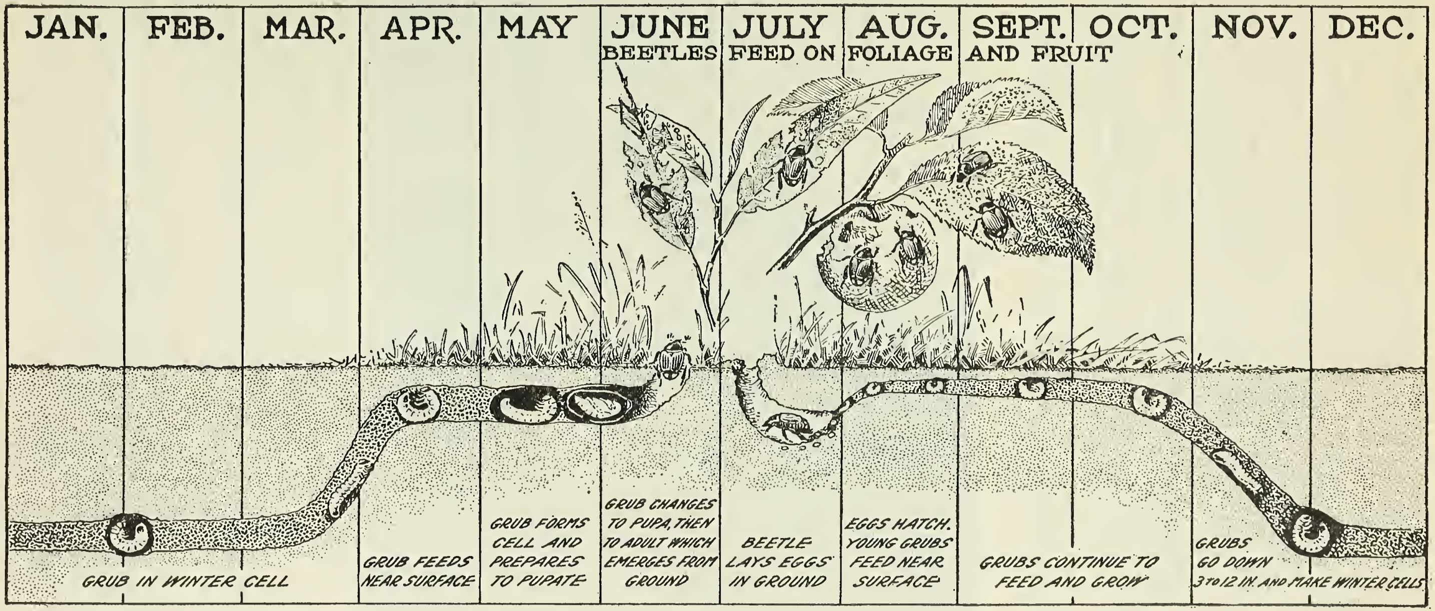


FIGURE 1.—Full-grown larva of the Japanese beetle. About five times natural size


JAN.
FEB.
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BEETLES FEED ON FOLIAGE AND FRUIT
GRUB IN WINTER CELL
GRUB FEEDS NEAR SURFACE
GRUB FORMS CELL AND PREPARES TO PUPATE
GRUB CHANGES TO PUPA, THEN TO ADULT WHICH EMERGES FROM GROUND
BEETLE LAYS EGGS IN GROUND
EGGS HATCH. YOUNG GRUBS FEED NEAR SURFACE
GRUBS CONTINUE TO FEED AND GROW
GRUBS GO DOWN 3 TO 12 IN. AND MAKE WINTER CELLS

FIGURE 2.—Diagrammatic presentation of the annual life cycle of the Japanese beetle

The density of the larval population in turf varies considerably with the season and the local conditions. In years with considerable rainfall during the summer the infestation is more uniformly distributed than in years of drought. In dry summers there is a tendency for the beetles to oviposit in the moist portions of the grasslands. The larvae are usually found in large numbers in open grasslands, but only rarely are many found in sod which is shaded.

Experience has shown that, with careful attention, a good sward can be maintained even though there be in each square yard of turf 100 to 150 larvae of either the Japanese beetle or the Asiatic beetle, or 150 to 200 larvae of the Asiatic garden beetle. If the growth of the grass is retarded by unfavorable environment, low fertility, or lack of moisture, a larval population of these densities is sufficient to cause extensive damage. It has been found impossible to maintain a good sward, even under favorable conditions, when the larvae are more numerous.

NATURE OF INJURY TO THE TURF

When the root system of grass is damaged by the feeding of the larvae, the turf may not be able to draw a sufficient supply of nutrients and moisture from the soil to maintain a good sward. The appearance of a lawn suffering from injury by these larvae is similar, in the early stages, to that of a lawn retarded by an inadequate supply of moisture or nutrients. If a portion of the sod is examined and a large number of larvae are found, one may be certain that they are causing the damage. As the injury becomes more extensive, the aerial portion of the grass is often completely severed from the roots. Turf which has been killed in this manner, as shown in Figure 3, can be rolled back easily by the fingers. A lawn seriously damaged by these larvae is soft and spongy because of the extensive burrowing of the insects immediately below the surface of the ground.

HOW LEAD ARSENATE KILLS LARVAE IN THE SOIL

Lead arsenate which satisfies the standard requirements of the chemical used as an agricultural spray is satisfactory for the treatment of turf. It should contain at least 30 per cent of arsenic pentoxide (As_2O_5).

The application of lead arsenate to turf does not prevent the adult beetle from laying eggs in the soil, but it destroys the larvae after they hatch. A larva takes soil into its stomach while feeding or burrowing. If the soil contains lead arsenate, this larva will eventually die. The period required for a larva to consume a deadly dose of lead arsenate depends upon the activity of the insect and the concentration of the poison in the soil. It is apparent that the greater the concentration of lead arsenate in the soil, the shorter the distance a larva can burrow before obtaining a fatal dose. When the poison is distributed uniformly throughout the layer of soil in which the larvae are feeding, several weeks may elapse before the insects are destroyed. The larvae, however, eat very little after the arsenic begins to affect them and soon become flabby and discolored.

When the lead arsenate is distributed only through the upper layer of soil, some of the larvae may continue to live for several months before consuming a fatal dose of the poison, because they remain most of the time below the poisoned layer. Although the application of lead arsenate in this manner is rarely exterminative, except in the case of a very light infestation, it has proved to be a practical method for reducing the density of the larval population below that which causes serious damage to the turf.

GRUB-PROOFING A LAWN IN THE PROCESS OF CONSTRUCTION

A lawn can be made practically immune to injury by larvae of Japanese and Asiatic beetles by mixing lead arsenate with the soil before the seed is sown. The ground is prepared for seeding according to the usual procedure by plowing, harrowing, raking, and leveling. In the northeastern sections of the United States it is generally recommended that these operations be carried on in the late spring and that the ground be maintained fallow by cultivation until the late summer or early fall, when the cooler temperature and increased rainfall are more conducive to the germination and growth of grass.

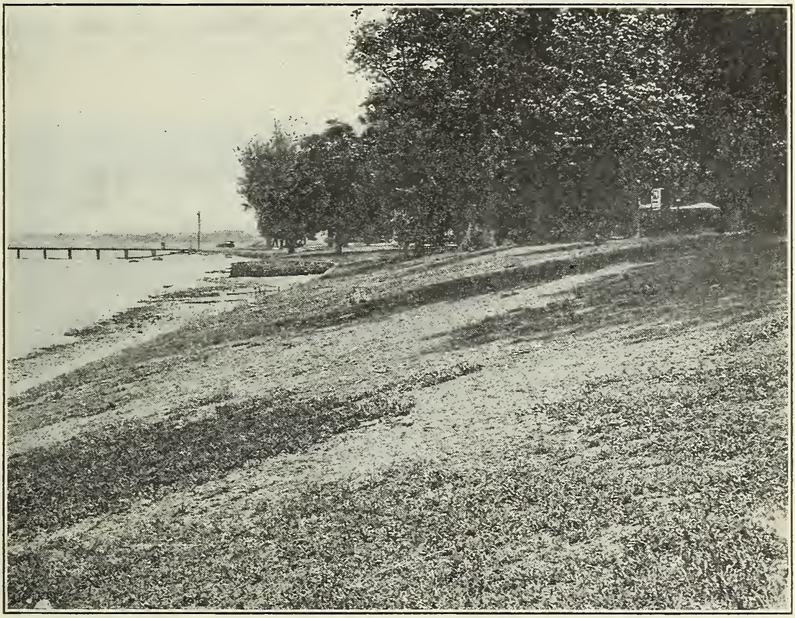

FIGURE 3.—A lawn injured by larvae of the Japanese beetle

The lead arsenate may be applied at any time of the year when the ground is not frozen, but it is most effective when in the ground before the eggs hatch. It is recommended that the lead arsenate be applied at the rate of 35 pounds to 1,000 square feet of surface and mixed to a depth of 3 inches.

The even distribution of lead arsenate to the necessary depth is essential for proper protection. It is difficult to spread 35 pounds of lead arsenate evenly over 1,000 square feet of surface without increasing its bulk with a suitable filler. It is, however, largely a matter of choice whether the lead arsenate is mixed with sand, soil, or an organic fertilizer. The quantity and the type of filler to be used will depend upon the preference and the skill of the individual and the method of application. If the mixture is to be applied by a fertilizer spreader, similar to those shown in Figure 4, the filler must be dry, finely screened, and free from a tendency to lump or stick; otherwise a uniform distribution may not be obtained. In mixing the chemical with the filler, it is necessary to pulverize all lumps and to obtain a uniform mixture. An excellent procedure for mixing small quantities is to spread the filler on a smooth tight floor, in a layer not more than 2 or 3 inches deep, and scatter the lead arsenate over the surface. The lead arsenate and filler are then raked and shoveled over several times until a uniform mixture is obtained. In mixing large quantities, a revolving concrete mixer can be used with satisfactory results. After the lead arsenate has been spread uniformly on the surface, the soil should be cultivated until the poison is distributed throughout the upper 3-inch layer.

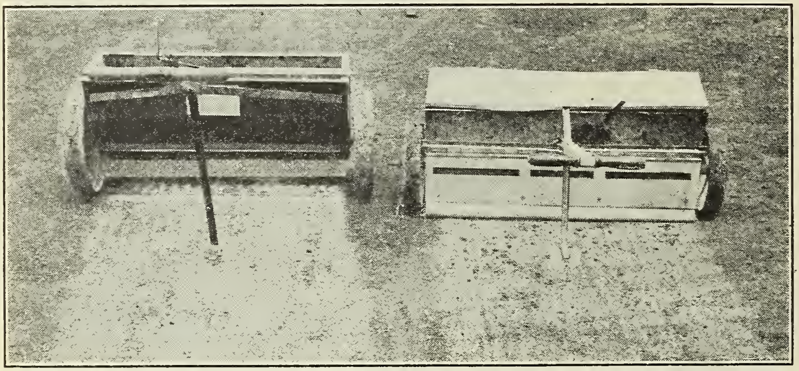

FIGURE 4.—Distributers for spreading lead arsenate

When the lead arsenate has been applied and mixed into the upper 3 inches of the soil, the grass is sown in the usual manner and the soil surface rolled. The grass is usually somewhat slower in germinating, the foliage darker, and the growth slower during the first few weeks in poisoned soil than in unpoisoned soil. After a turf of most of the common grasses has become established on poisoned soil, there is usually little difference in the appearance of the sward from that on unpoisoned soil. It has been found that Kentucky bluegrass (*Poa pratensis*), redtop (*Agrostis palustris*), perennial ryegrass (*Lolium perenne*), and Chewings red fescue (*Festuca rubra*), which are usually included in the grass mixtures for lawns, grow satisfactorily in ground containing lead arsenate. White clover (*Trifolium repens*) appears to be uninjured. Annual bluegrass (*Poa annua*) and the rough-stalked bluegrass (*P. trivialis*), which are commonly grown in shady locations, are sometimes killed by lead arsenate.

Mowing, watering, and other operations may be carried on as usual on treated land. No harmful effects have been observed by the application to treated turf of such fertilizers as well-rotted manure, ammonium sulphate, sodium nitrate, potassium chloride, superphosphate, bone meal, and lime. The inorganic fertilizers, however, must be applied carefully in order to avoid superficial injury to the foliage. The addition of lime to poisoned turf is not recommended because it has been found to reduce the insecticidal value of the treatment. Lime should be used on poisoned turf only when necessary to correct the acidity of the soil.

The application of lead arsenate to turf at the rate of 35 pounds to 1,000 square feet has been known to make the turf practically immune to larval injury for many years. A chemical analysis of turf treated in this manner shows that, on the average, less than 10 per cent of the arsenic had been lost from the upper 3 inches of soil after two years. It is to be expected that a lawn treated in this manner will be immune to injury by the larvae of these insects for a period of at least 10 years.

GRUB-PROOFING AN ESTABLISHED LAWN

It is possible to make an established lawn practically immune to injury by these insects by building up a poisoned layer of soil at the surface. In view of the feeding habits of the insects, the density of the larval population can be kept below the number which will cause serious damage by having sufficient lead arsenate in the upper inch of soil. An application of lead arsenate at the rate of 5 pounds to 1,000 square feet of turf before the period of oviposition has been found to reduce a light infestation of 100 to 150 larvae to a square yard so that damage did not occur, but this treatment did not prevent serious damage when the infestation was 400 or more larvae to a square yard. In order to protect lawns in heavily infested localities it has been found necessary to use not less than 10 pounds of lead arsenate to each 1,000 square feet of surface, and protection is more assured when the chemical is used at the rate of 15 pounds to this area.

The effectiveness of the treatment depends upon the presence of a poisoned layer at the surface of the soil of sufficient concentration that the larvae are so reduced in numbers as to make possible the maintenance of a sward. Chemical analysis of treated lawns in different localities in the Eastern States shows that only a small part of the arsenical applied to the surface penetrates below 3 inches and that most of the poison remains in the upper inch of the soil. It is possible, therefore, to apply the treatment of 15 pounds in one application, or gradually build up the poisoned layer of soil by successive applications. When it is the practice to apply top-dressings to the turf throughout the season, lead arsenate should be mixed with each top-dressing to avoid building up an unpoisoned layer at the surface. In any case, the initial application of lead arsenate should be made before July.

These small quantities of lead arsenate must be diluted to a greater bulk in order to obtain a uniform distribution over the surface. It is largely a matter of choice whether the chemical is applied in water, or in a dry state mixed with sand, soil, or other material. The use of a relatively insoluble chemical like lead arsenate with water necessitates sufficient agitation to keep the material in suspension.

In applying the lead arsenate with water, as shown in Figure 5, it should be mixed with the smallest possible volume of water in order to obtain a uniform distribution without flooding the turf. When power sprayers were used satisfactory results have been obtained with a mixture containing 1 pound of lead arsenate to 2 gallons of water, and in some cases with a concentration of 1 pound of the chemical to 1 gallon of water. A Worthley nozzle with a baffle and a pressure of 250 to 300 pounds has given a good distribution of the chemical. A power sprayer is usually too heavy to take on the average turf, so it must be placed at the most advantageous position, and one or more lines of hose laid to the area to be treated. The man at the nozzle begins to apply the spray at the point most remote from the sprayer, assisted by as many men as are required to keep the heavy hose and the hose connections from dragging on the turf. With a little experience, a man can adjust his gait to the rate at which the spray is flowing, so that the required quantity of chemical is applied. After the spray is applied, the turf should be well watered to wash the material off the grass before the spray dries.

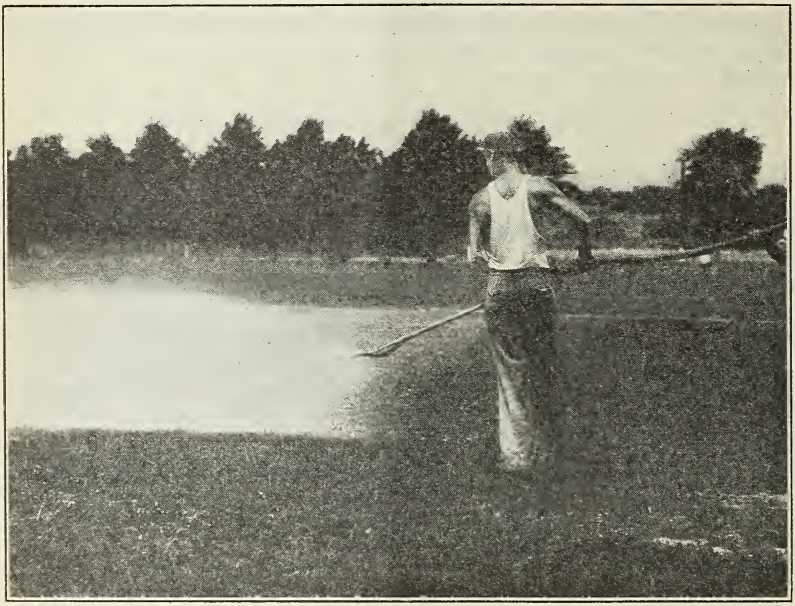

FIGURE 5.—Applying lead arsenate as a spray to turf

In treating a comparatively small area with lead arsenate in a dry state, the chemical may be mixed with about 25 times its volume of moist sand, soil, or other suitable material, and broadcast by hand.

Many people prefer to apply lead arsenate to a large area in a dry state because this method does not require expensive equipment. Several relatively inexpensive distributers are now available on the market. When the mixture is applied in a distributer, it must be finely ground, dry, and free from a tendency to clog. The most satisfactory of the lead arsenate mixtures, of those tested for application in a distributer, are as follows:

(1) 1 part of lead arsenate, 4 parts of activated sludge, by weight.
(2) 1 part of lead arsenate, 2 parts of activated sludge, 4 parts of sand, by weight.
(3) 1 part of lead arsenate, 2 parts of tankage, 4 parts of sand, by weight.
(4) 1 part of lead arsenate, 10 parts of sand, by weight.

It is possible to prepare these mixtures some time before applying them to turf, but it is advisable to mix them a short time before use, because in some cases it was found that the mixtures became somewhat lumpy after being in storage for one year and did not give a satisfactory distribution of the chemical.

The above-mentioned mixtures have been applied to turf as top-dressings without causing injury. When inorganic fertilizers were added to the mixture some injury resulted in a few cases. It is recommended, therefore, until further information can be obtained, that the inorganic fertilizers be excluded from the mixture.

After the lead arsenate has been applied, either as a spray or in the dry state, to turf, the normal operations of mowing, watering, and fertilizing can be carried out, but the precautions indicated for the care of turf on poisoned ground should be observed.

It is difficult to predict how long lawns top-dressed with lead arsenate will remain immune to injury by the larvae, as this will depend upon the quantity of lead arsenate applied, the soil conditions, and the density of the infestation. It is to be expected that under normal conditions an application of lead arsenate at the rate of 15 pounds to 1,000 square feet will protect the turf from injury for at least 5 years.

TREATMENT OF INJURED TURF

It is better to prevent injury to turf by applying the lead arsenate before the density of the larval population is sufficient to cause damage to the grass, but if this has not been carried out, treatment should be made as soon as injury becomes apparent. Lead arsenate can be applied at any season when the ground is not frozen, but the best results are obtained when applied before July.

The portions of the turf which have been ruined by the larvae should be dug and the seed bed prepared according to the recommendations for the grub-proofing of a lawn in the process of construction, using lead arsenate at the rate of 35 pounds to 1,000 square feet and mixing it into the soil to a depth of 3 inches. The remainder of the turf which has not been so severely injured should be top-dressed with lead arsenate at the rate of 15 pounds to 1,000 square feet of surface.

PRECAUTIONS ON THE APPLICATION OF LEAD ARSENATE

Lead arsenate is poisonous to man and to animals. Considerable care should be exercised in handling it in order to avoid inhaling the dust. It may be mixed and otherwise manipulated with the bare hands, but, since there is a possibility that the poison may be absorbed into the system through cuts and abrasions of the skin, it is advisable to protect the hands. The worker should keep the hands away from the mouth and wash them thoroughly before eating.

The application of lead arsenate should be limited to the turf which is to be protected from larval injury. It should not be applied to flower gardens, shrubbery borders, or vegetable gardens. The available evidence shows that some ornamental plants will not grow in soil containing lead arsenate. Although some vegetables have been grown satisfactorily in land containing lead arsenate, and the available evidence indicates that little of the poison is absorbed, it is recommended that, until more extensive information is obtained, no treatments be applied to vegetable gardens.

The use of lead arsenate is recommended for lawns and golf courses, but it is not recommended for pasture land and other grasslands which are used for grazing or ranging purposes. There is no evidence at present to show that horses, cattle, sheep, or poultry have been poisoned by feeding on vegetation growing on soil to which lead arsenate has been applied, but as a precaution it is advisable not to apply the chemical on land that is to be used in this manner. The extensive use of lead arsenate on turf within the infested area has not caused any known damage to the native birds which feed on earthworms and grubs in the soil. It is advised that children be kept from playing on recently poisoned turf until the lead arsenate has been removed from the foliage.

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